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AN INVESTIGATION OF MINIMAL EQUIPMENT NEEDS IN PERSONNEL SHELTERS

by

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APPROACH

This study is concerned with equipment needs for personnel survival in blast resistant shelters following a nuclear attack. In this contract, the term "equipment" is considered to include all life support systems, supplies, furnishings, and auxiliary features which may be required to make the shelter self-sufficient and sustain the life of its occupants for that period of time until evacuation and relocation can be carried out in safety. The emphasis of this program is on establishing the basic survival requirements and seeing how these can be met at a minimum cost. Comparative requirements for shelters accommodating 100, 500 and 1000 persons have been investigated.

For a program of this nature, a realistic research methodology requires that pertinent factors related to or influencing the chances of surviving a nuclear attack and the hazardous post-attack period be established and identified. Even though one can only assume the intensity of the attack environment for any particular shelter, these assumptions and the chosen level of protection designed into mass shelters must be based on available scientific data. In addition to the hazards directly related to the attack and the contaminated post-attack outside environment, there are dangers associated with the prolonged crowded occupancy of a shelter. These dangers, associated with the life sustaining requirements and functions of the human body, were identified and the severity of these dangers established. On the basis of these findings, the requirements for the most effective shelter operation as well as equipment needs were established. The effect of a shelter's geographic location and also the time of year were investigated to determine the influence of the shelter's normal environment on the complexity of needed equipment to provide marginal survival conditions. Local conditions influencing these findings included outside air temperature, air humidity, diurnal temperature changes, ground temperature at various depths, depth to ground water or water level, and ground water temperature. In order to test the validity of the investigative approach, four examples representing diversified locations and local conditions were subjected to an analysis on the basis of available information. Equipment needs established for these four extreme conditions were found to be attainable within the general equipment concept established during this investigation

The report is divided into seven major chapters with a bibliography supplied as an eighth chapter. The first chapter describes the research approach used in the study and briefly points out the basic problems which are associated with prolonged shelter occupancy These are the problems that must be confronted by the shelter's equipment system(s) in order to provide the means to sustain the lives of the occupants. The second chapter deals with the attack environment or effects that may be directly related to the detonation of a nuclear bomb. The immediate effects of an explosion, such as blast, thermal radiation and initial nuclear radiation, are not of major concern to this program. The central problem is that life be sustained in a shelter surviving the actual attack Under these circumstances, it is necessary to ascertain the aftermath or lingering effects of a nuclear attack and how these may influence the survival of persons having found refuge in a shelter. Chapter Two develops this necessary background information and concentrates on the intensity and time-related decay of dangers associated with fire, debris pile-up, smouldering rubble, radiological fallout. and the substances of bacteriological and chemical warfare.

Chapter Three undertakes the problem of defining the physiological factors necessary for survival. In other words, the minimum needs of human beings and tolerance limits of endurance to the build-up of a hostile environment. The basic requirements to sustain life are food, water and oxygen and these needs are established However, the human body in its functions generates and rejects unwanted substance which in concentrated form would be hazardous to sustaining life In the confines of a crowded shelter the build-up of these substances would become dangerous unless appropriate countermeasures are taken. Aside from dealing with the management and isolation of human waste, Chapter Three also concerns itself with the way the human system responds to various concentrations of carbon monoxide in air. In addition, a great emphais is placed on a body's capability to generate heat and water vapors. The build-up of these two qualities in the air greatly influences the resulting effective temperature which in turn indicates the degress of thermal stress to which a body is being subjected.

Chapter Four considers exclusively the major self-induced hazard of a crowded fully-buried shelter for extended occupancy, namely, the internal thermal environment. Each occupant generates a given amount of heat (BTU) over a period of time so that the shelter is subjected to a constant and

steady heat flux Since human beings have definite limitations as to the thermal stress to which they can be subjected the allowable shelter temperature build-up is limited. Thus provisions must be made to allow the generated heat to be removed once the limiting effective temperature is reached. This chapter investigates the effectiveness of the shelter structure and its surrounding earth as a heat sink for various conditions found throughout the United States. The effects of ground temperature ground consistency, and its moisture content are established. For prolonged shelter occupancy. when ventilation is possible, the required ventilation rates for temperature control are established for diversified locations and climatic conditions

Chapter Five summarizes the findings of the previous chapters and establishes design parameters that the shelter's equipment will have to meet. On the basis of the information established in the previous chapters, it is also postulated that a shelter may have to be occupied for as long as fourteen (14) days. In turn this period needs to be divided into two separate methods of operation. For the initial procedure lasting up to three (3) days, the shelter will be completely sealed or closed against the outside environment. For the remaining time, shelter ventilation by outside air is possible, however safeguards against contamination may still be necessary.

Chapter Six investigates the alternative equipment systems that may be used to counteract the various hazards associated with prolonged shelter occupancy. Wherever applicable, the problem is broken down to the conditions existing for both the open and closed period of shelter occupancy. For each problem area we restate and clarify the problem and point out the methods that could possibly be considered as its solution. In addition, the objectionable side effects that may be associated with a method, as well as power requirements, complexity of the process, and cost considerations are investigated.

Chapter Seven delves into the specifics of equipment selection for four separate and difficult climate conditions as found within the confines of the United States. Though some of the input data used in these analyses was unknown and thus assumed, the procedural steps taken may serve as examples for determining the requirements for specific situations The examples, however, do point out that shelters can be equipped with equipment systems

that will protect its occupants against anticipated hazards. The system modifications necessitated by possible extremes of the outside environment are found to be relatively minor.

FINDINGS

The major findings of this study are:

1. Shelter equipment needs are based on the premise that the shelter survived the actual nuclear attack. On this basis, the equipment should be suitable to sustain life in the shelter for the necessary post-attack period until evacuation can be realized in safety.

2. The total period of shelter occupancy can be as long as 14 days. During the initial phase (up to three days) the shelter should be effectively closed or sealed against the outside atmosphere. The concentration of radiation, smoke, carbon monoxide and chemical and bacterial warfare agents may be critical for this length of time. For the remainder of the time the shelter can be ventilated with outside air; however, means for its filtration or purification should be provided to bring its possible remaining contamination down to a safe level.

3 The build-up of heat and humidity within a shelter, due to the metabolic functioning of its occupants, is one of the main hazards. Thus temperature and humidity control is of primary importance. The shelter and its surrounding earth mass is not a sufficient and dependable heat sink for more than the initial 24 hours of sealed occupancy. Even the ventilation of the shelter's open period would be insufficient during the summer months. A more reliable and, temperature-wise, constant heat absorbing and transporting media can be found in well water. It would be available for both the shelter's closed and open periods. Its most efficient method of utilization is advocated since the pumping power would be manual.

4. Oxygen requirement for the three days of the closed period will have to be stored. For the open period a relatively small ventilation rate will maintain the shelter's O_2 content at an acceptable level.

5. During the closed period the carbon dioxide given off by the breathing of the occupants will reach an unsafe level within a short period of time. A chemical reaction process that will remove the CO_2 from the air will be necessary. For the open period one again needs only a relatively

small ventilation rate to maintain the CO_2 content of the shelter's air at an acceptable level.

6. Shelter ventilation is unreliable except for oxygen and carbon dioxide control. The small amount required for this purpose can, if necessary, be filtered and treated and the power required for forced circulation can be supplied manually. However, large ventilation rates cannot be relied upon since the atmosphere degree of contamination is unpredictable. The purification of large volumes of air is not practical since the flow resistance for filtration, etc., is high and power requirements would be excessive.